



ASSESSMENT OF DIVISIONS 2G-3K NORTHERN SHRIMP

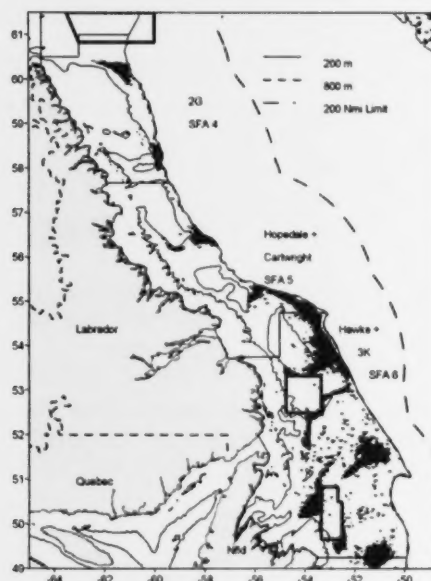


Figure 1. Map of northern shrimp fishing areas (SFAs) including the Coral, Hawke Channel and Funk Island Deep closed areas. The red crosses indicate large and small vessel fishing positions during 2009.

Context :

The bottom trawl fishery for northern shrimp off the coast of Labrador began in the mid 1970s, primarily in the Hopedale and Cartwright (SFA 5) Channels. It expanded north and south through the 1980s. Catches increased from 23,000 t in 1994 to 111,000 t in 2003. The management year for shrimp fishing areas 4-6 changed from a calendar year to April 1–March 31 in 2003. Between 2003/04 and 2007/08 TACs remained at 112,000 t then increased to 120,000 t in 2008/09 remaining at that level in 2009/10.

DFO Fisheries and Aquaculture Management has requested science advise on the status of northern shrimp in Shrimp Fishing Areas (SFAs) 4, 5 and 6. This resource is assessed on a biennial schedule and was last assessed in March 2008.

A formal assessment of the resource was conducted during March 24-26, and 29-31, 2010. The assessment made use of fishery data from observer and logbook datasets when estimating catch rate indices and indices of fishery aggregation. Bottom trawl surveys provided indices of recruitment, spawning stock biomass, fishable biomass and exploitation rate.

This report provides a summary of key results of the assessment, a narrative describing the fishery with an expanded discussion of resource status and outlook.

SUMMARY

- Resource status was updated based on a Fisheries and Oceans Canada (DFO) fall multi-species research vessel (RV) bottom trawl survey series (1996-2009), which provided information on distribution, abundance, biomass, recruitment, size, and sex composition in the Div. 2J portion of SFA 5 and Hawke Channel + Div. 3K (SFA 6). Trends in stock size were also inferred from fishery catch per unit effort (CPUE) and fishing patterns.
- The Northern Shrimp Research Foundation (NSRF) in partnership with DFO conducted annual shrimp based research surveys in Division 2G (SFA 4) during 2005-2009.
- The resource has been decreasing in the south but increasing in the north.

SFA 6 (Hawke Channel + Division 3K)

- Catches increased from 11,000 t in 1994 – 1996 to 78,000 t by 2004/05 and changed little to 2008/09. The 2009/10 TAC was set at 85,725 t but will not be caught largely due to commercial/ operational factors.
- Spatial distribution of the resource and large vessel fishery changed little over recent years. The spatial distribution of the small vessel fishery increased from 1998 to 2007 then decreased to 2009.
- The large (>500 t) vessel CPUE remained at a high level between 1995 and 2006 after which it decreased to 2009. The small vessel (<100 ft) CPUE increased to 2003, remained high until 2007 and then decreased to 2009.
- Biomass indices (total, fishable and female) from fall multi-species surveys generally increased from 1997 to peak levels in 2006 but have since decreased by 50%.
- The recruitment index has been variable, peaking in 2006, but has since declined to the long term average.
- Female spawning stock biomass (SSB) is presently within the cautious zone at 97% of the provisional Upper Stock Reference Point (USR).
- Harvesting the current TAC of 85,725 t in the next management year would cause the 2010/11 exploitation rate index, based upon fishable biomass, to increase to 28%.

SFA 5 (Hopedale and Cartwright Channels)

- Catches increased from 15,000 t in 1997-2002 to around 23,000 t in 2004/05- 2008/09. The 2009/10 TAC was set at 23,300 t and it is anticipated that the TAC will be taken.
- CPUE has been trending upward since 1992 and has been above the long term average since 1995.
- Surveys of the whole of SFA 5 were completed in only four (2001, 2004, 2006, 2008) of the last ten years.

- SFA 5 fishable biomass indices declined by 16% from 2006 to 2008.
- Fishable biomass in Cartwright Channel, surveyed every year, decreased by 40% in 2009. Broad confidence intervals in 2009 indicate uncertainty.
- Recruitment in the short-term, while uncertain, appears average.
- SSB in SFA 5 was in the healthy zone in 2008, well above the provisional USR.
- Exploitation rate index was 20% in 2008, slightly above the long term mean.

SFA 4 (Division 2G)

- Catches increased from 4000 t in 1994 to 10,000 t in 2004/05 and remained at that level until 2008/09. The 2009/10 TAC was set at 11,320 t and it is anticipated that the TAC will be taken.
- CPUE has increased since 2004/05 and is now well above the long term mean.
- The NSRF-DFO research survey biomass indices (total, female and fishable) have been increasing throughout the five-year time period.
- The recruitment index increased from 2005 to 2008 and has changed little in 2009.
- Exploitation rate indices have decreased from 16% in 2005 to 6% in 2009.
- SSB is currently in the healthy zone, well above the provisional USR.

BACKGROUND

Species Biology

Northern or pink shrimp (*Pandalus borealis*) are found in the Northwest Atlantic from Davis Strait to the Gulf of Maine, usually in areas where the ocean floor is soft and muddy and where temperatures near the bottom range from about 1°C to 6°C. These conditions occur throughout the Newfoundland and Labrador offshore area within a depth range of roughly 150-600 m, thus providing a vast area of suitable habitat. The species is the primary cold-water shrimp resource in the North Atlantic.

These shrimp are protandrous hermaphrodites. They first mature as males, mate as males for one to several years and then change sex to spend the rest of their lives as mature females. They are known to live for more than eight years in some areas. Some northern populations exhibit slower rates of growth and maturation but greater longevity results in larger maximum size. Most of the fishable biomass is female.

The shrimp are thought to begin to recruit to the fishery at age three, but may not be fully recruited until much later.

During the daytime, northern shrimp rest and feed on or near the ocean floor. At night, substantial numbers migrate vertically into the water column, feeding on zooplankton. They are important prey for many species such as Atlantic cod, Greenland halibut, skates, wolffish, snow crab and harp seals.

Fishery

The fishery for northern shrimp off the coast of Labrador began in the mid 1970s, primarily in the Hopedale and Cartwright (SFA 5) Channels (Fig. 1). Annual catches (Fig. 2) increased steadily from less than 2700 t in 1977 to about 4100 t in 1981 but subsequently declined to 1000 t in 1983 and 1984 due to poor markets and high operating costs. Economic conditions improved thereafter, and catches from SFAs 5 and 6 increased to about 7800 t in 1987. In 1988, fishing effort became more widespread as vessels ventured into Division 2G (SFA 4) where both catch rate and size of shrimp proved to be very attractive to the industry. Additional commercial concentrations of shrimp were located within SFA 6 in a small area east of St. Anthony Basin and in the Funk Island Deep. Catches in both 1988 and 1989 approached 17,000 t and remained in the 14,000-20,000 t range from 1990 to 1993. Exploratory fisheries along the slope of the shelf in SFAs 4, 5 and 6 in 1992 and 1993 revealed commercial concentrations of shrimp in those areas, as well.

Catches from 1994 to 1996 averaged 23,000 t increasing to 85,000 t by 2000, following increases in TAC within SFA 6 where the resource was considered to be healthy and exploitation low. The increases after 1996 were primarily reserved for the development of a small vessel (< 100 ft) fleet which has since grown to include more than 300 vessels.

The overall TAC increased by 25,000 t in 2003. During that year industry was granted a change in management year from calendar (Jan. 1 – Dec. 31) to fiscal (Apr. 1 – Mar. 31). To facilitate this change, an additional 20,229 t interim quota was allocated to the large vessel fleet and the 2003/04 management period became 15 months in length. The 2004/05 management year was 12 months in duration and total allocations equaled 111,552 t. This TAC was maintained until 2008/09 when the TAC was increased to 120,344 t. This TAC was maintained through to 2009/10; however, due to operational and commercial constraints, the TAC was not taken.

All northern shrimp fisheries in eastern Canada are subject to the Atlantic Fisheries Regulations regarding territorial waters, by-catches, discarding, vessel logs, etc. The regulations include a minimum mesh size of 40 mm and sorting grates to minimize by-catch of non-target species. Grate size is dependent upon area fished and vessel class. Observers are required on all trips by the large vessel fleet and a target of 10% coverage has been established for the small vessel fleet.

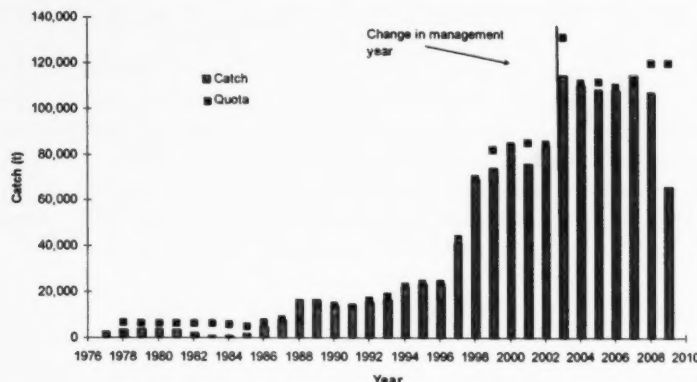


Figure 2. Historical northern shrimp catches (SFAs 4-6) and TACs for the period 1977-2010 (2009/10 catches are preliminary). In 2003, the management year changed to a fiscal year.

ASSESSMENT

Resource status was evaluated based on trends in fishery Catch Per Unit Effort (CPUE) derived from logbooks and observer datasets, indices from DFO autumn multi-species bottom trawl surveys in Divisions 2HJ3K, a joint Northern Shrimp Research Foundation (NSRF)-DFO summer shrimp-based survey in Division 2G, as well as biological sampling from multiple sources.

The bottom trawl surveys provide indices of recruitment, total abundance, female spawning stock biomass (SSB), fishable biomass, and total biomass. Recruitment indices (abundance of males and females with 11.5 - 16 mm carapace length, primarily age 2) provide prospects of biomass two years later. The fishable biomass is defined as the weight of all males and females with a carapace length > 17 mm. Exploitation rate indices were determined by comparing the catch to the survey fishable biomass index (catch/ previous year autumn fishable biomass index for SFAs 5 and 6; catch/ current year summer fishable biomass index for SFA 4). These indices provide an upper bound for exploitation rates because survey catchability is less than one.

The precautionary approach was applied using an Upper Stock Reference (USR = 80% of the geometric mean of SSB over a productive period) and a Lower Reference Point (LRP = 30% of the geometric mean of SSB over a productive period) superimposed upon the exploitation rate trajectory over time. Due to differences in survey history and schedules the respective productive time periods were thought to be 1996 - 2003 for SFA 6, 1996 - 2001 for SFA 5 and 2005 - 2009 for SFA 4.

SFA 6 (Hawke Channel + Division 3K)

Commercial Fishery:

The TAC was set at 11,050 t in 1994 and increased to 23,100 t in 1997 (Fig. 3) as a first step towards increasing the exploitation of an abundant resource. Most of the increase was reserved for development of the small vessel fleet. The TAC more than doubled between 1997 and 1999, increased slightly to 2002 and further increased, by 26%, to 77,932 t in 2003. An

additional interim quota of 7653 t was set for the fishing season January 1 – March 31, 2004 to facilitate an industry requested change in fishing season from April 1 – March 31. Thus the 2003/04 management period was 15 months long and had an 85,585 t TAC. The 2004/05 management year was 12 months, had a 77,932 t TAC. During 2007 a seasonal bridging program was established that allowed fishing companies to fish up to 250 t of unused quota from the preceding year or take from the next year's quota. As a result of this seasonal bridging program, the 77,932 t set TAC for 2007/08 was allowed to be exceeded by 2000 t. The TAC was increased to 85,725 t in 2008/09 and maintained through to 2009/10. Due to operational/commercial factors, the TAC was not taken during either of these years.

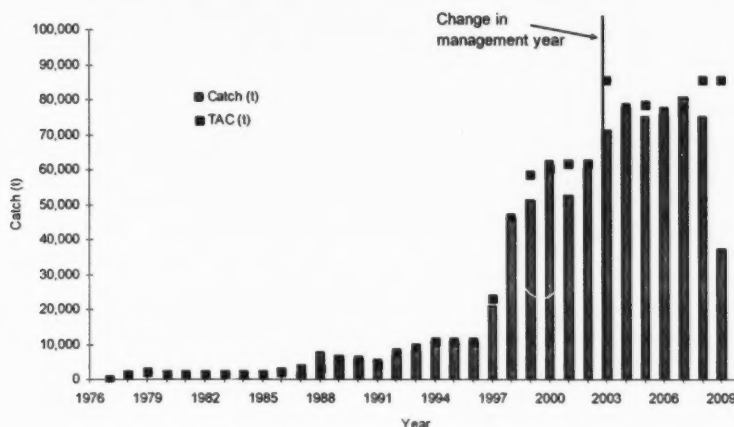


Figure 3. Historical northern shrimp catches (SFA 6) and TACs for the period 1977-2010 (2009/10 catches are preliminary). In 2003, the management year changed to a fiscal year.

The large (>500 t) vessel CPUE remained at a high level between 1995 and 2006 after which it decreased to 2009. The small vessel (<100 ft) CPUE increased to 2003, remained high until 2007 and then decreased to 2009 (Fig. 4).

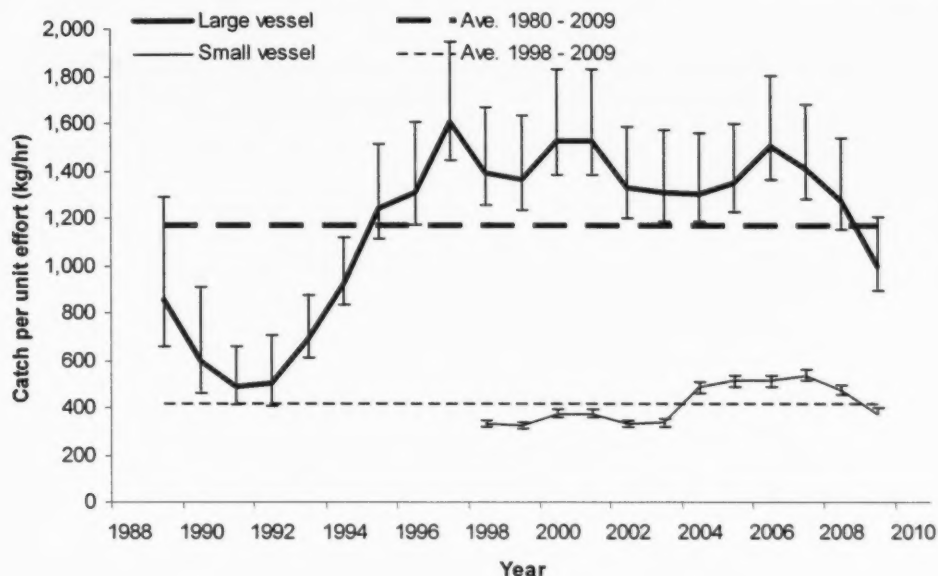


Figure 4. SFA 6 large and small vessel CPUE (error bars indicate 95% confidence intervals).

Spatial distribution of the resource and large vessel fishery changed little over recent years. The spatial distribution of the small vessel fishery increased from 1998 to 2007 then decreased to 2009 (Fig 5).

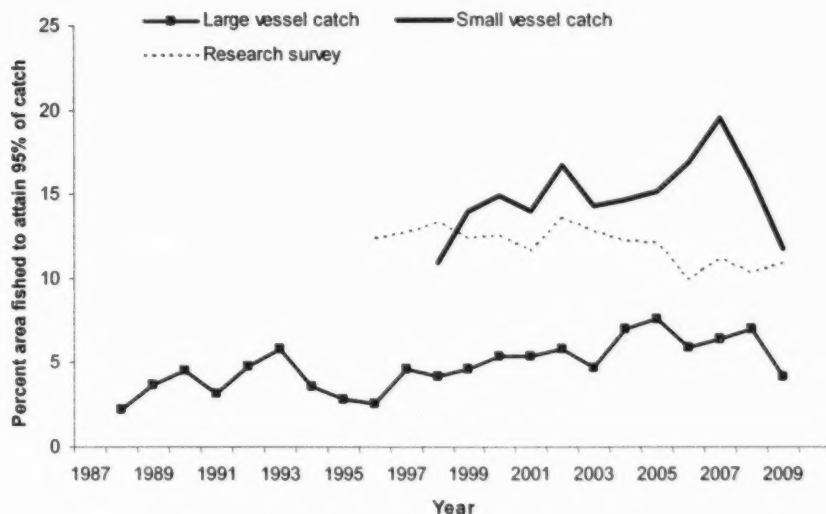


Figure 5. Percent of the total area available within SFA 6 necessary to account for 95% of the research and commercial catches over the period 1989-2009.

Biomass

Biomass indices (total, fishable and female) from fall multi-species surveys generally increased from 1997 to peak levels in 2006 but have since decreased by 50% (Fig 6). Both indices dropped below the long term average in 2009.

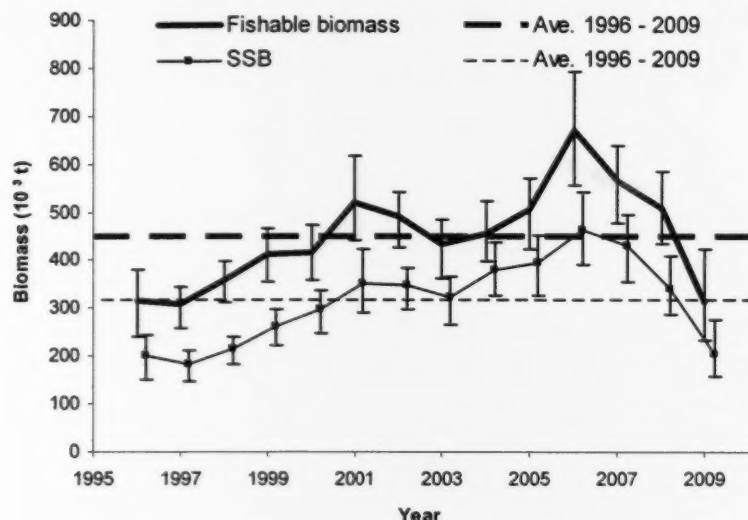


Figure 6. SFA 6 biomass indices (error bars indicate 95% confidence intervals).

Recruitment

Recruitment indices have been variable, peaking in 2006, but have since declined to the long term average (Fig. 7). The apparently strong 2004 year class (2006 index) did not lead to increased fishable biomass. The relationship between recruitment index and fishable biomass is uncertain.

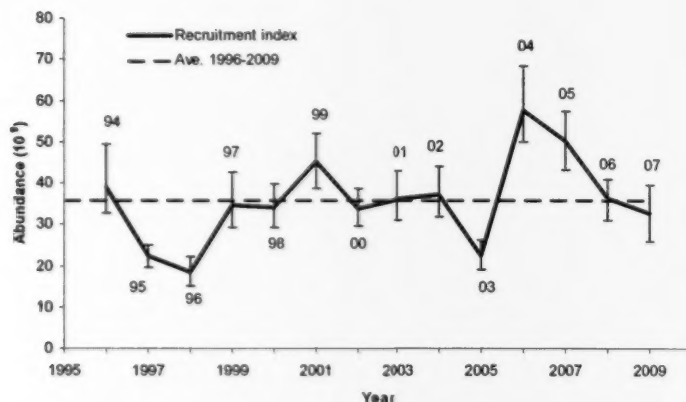


Figure 7. SFA 6 recruitment index (error bars indicate 95% confidence intervals; numbers denote year classes).

Mortality

Even though catches remained high over the period 2004 – 2007 (Fig. 3), the exploitation rate index decreased as a result of increased fishable biomass over the period 2003 – 2006 (Fig. 8). Harvesting the current TAC of 85,725 t in the next management year would cause the 2010/11 exploitation rate index, based upon survey fishable biomass, to increase to 28%.

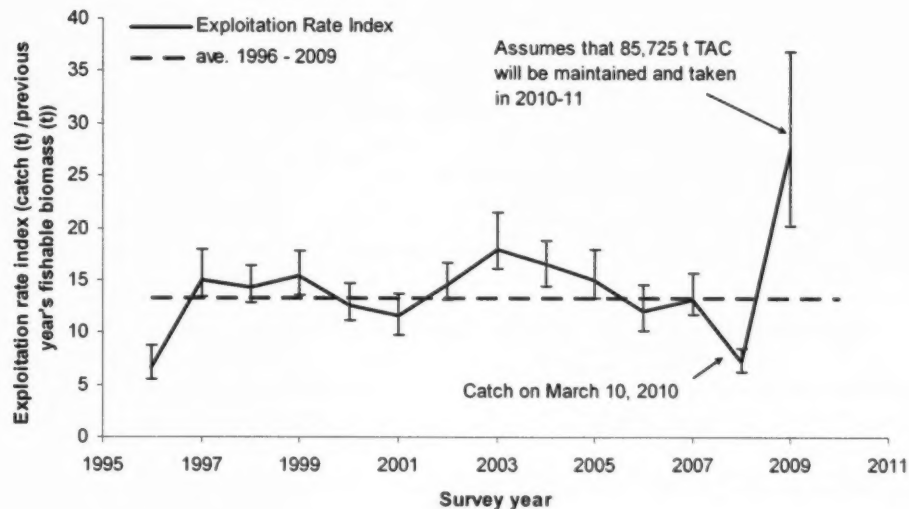


Figure 8. SFA 6 exploitation rate index (total catch/ fishable biomass index from the previous year; error bars indicate 95% confidence intervals). The 2009/10 fishery was ongoing therefore catch was incomplete.

Instantaneous mortality (Z) for females was estimated to be approximately 1, which equates to an annual mortality rate (A) of 63% per year.

In terms of the precautionary approach framework, SSB is presently within the cautious zone at 97% of the provisional USR (Fig 9).

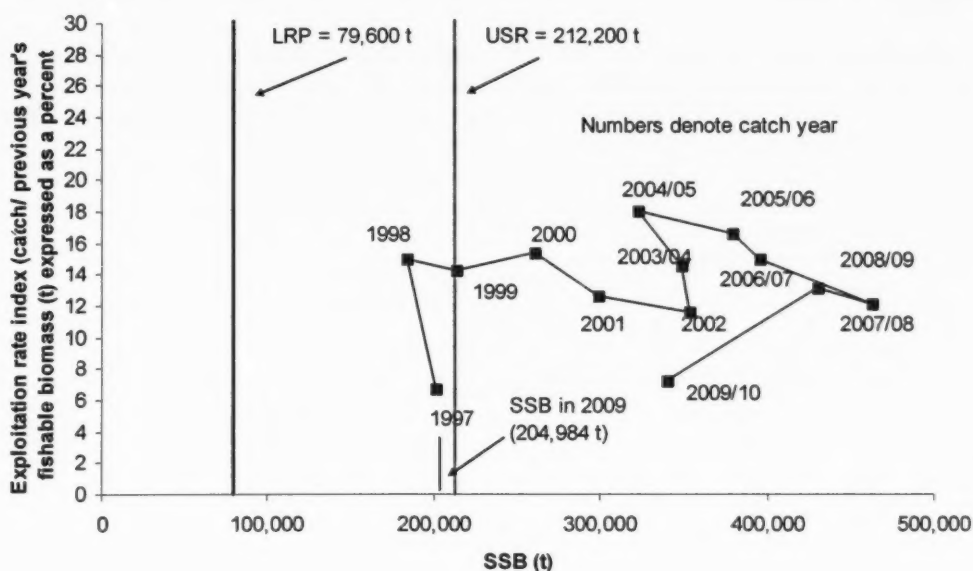


Figure 9. SFA 6 precautionary approach framework with trajectory of exploitation rate index vs SSB.

SFA 5 (Hopedale and Cartwright Channels)

Commercial Fishery

The TAC doubled from 7650 t during 1994 - 1996 to 15,300 t over the 1997-2002 period. In 2003, the TAC increased 52% to 23,300 t, the management year changed to April 1 - March 31, and an additional interim quota of 9,787 t was set for the period January 1 - March 31, 2004. Thus the 2003/04 management period was 15 months long and had a 33,084 t TAC. The 2003/04 management year TAC (23,300 t) was maintained through to 2009/10. The TAC has been taken in most years. Approximately 19,000 t were taken during the 2009 calendar year and it is anticipated that the remainder of the TAC will be taken (Fig. 10).

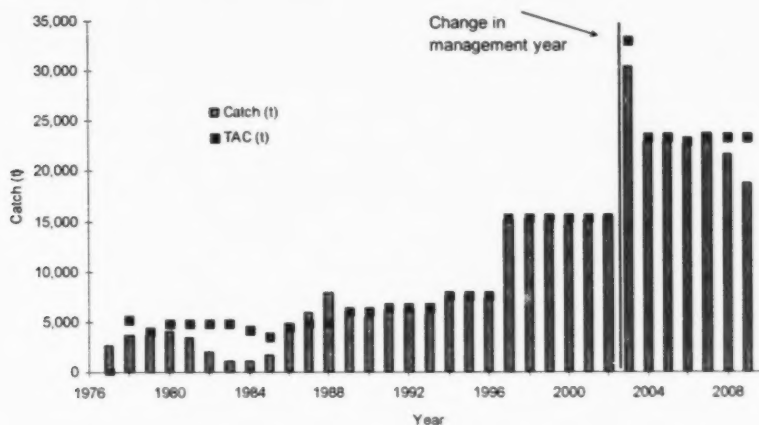


Figure 10. Historical northern shrimp catches (SFA 5) and TACs for the period 1977-2010 (2009/10 catches are preliminary). In 2003, the management year changed to a fiscal year.

CPUE has been trending upward from 1992 to 2001 and has been above the long term average since 1995 (Fig. 11).

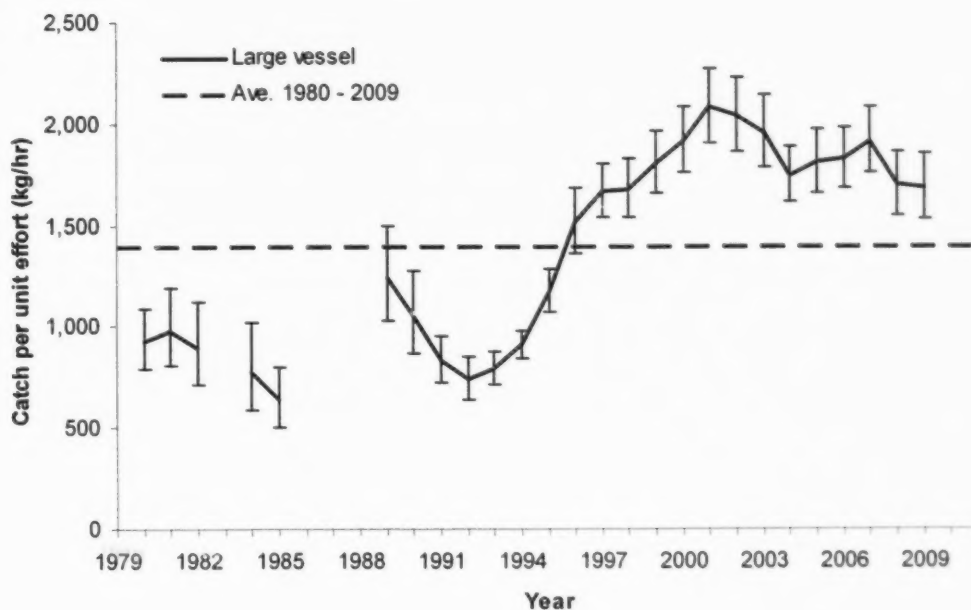


Figure 11. SFA 5 large vessel CPUE (error bars indicate 95% confidence intervals).

Percent total area fished within SFA 5 for the large (>500 t) vessel fleet to obtain 95% of their catch increased from 5 – 11% over the period 1985 – 2006, but has since decreased to the long term mean (Fig 12). It is a concern that the area fished has been decreasing while the CPUE is

being maintained at a high level, suggesting the resource may be becoming locally aggregated. However, the decrease has been over a short time period and could be part of natural variation.

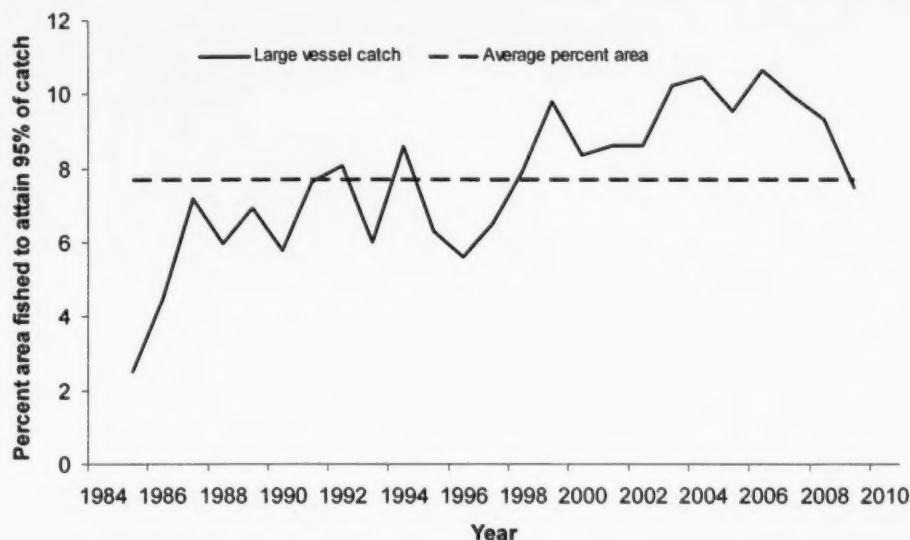


Figure 12. Percent of the total area available within SFA 5 necessary to account for 95% of large commercial catches over the period 1980 – 2009.

Biomass

Annual autumn multi-species surveys were conducted in the northern part of SFA 5 (NAFO Division 2H) between 1996 and 1999. Since then, surveys of the whole of SFA 5 were completed in only four (2001, 2004, 2006, 2008) of the last ten years. However, the southern portion of SFA 5 (Cartwright Channel) has been surveyed during all years since 1996. In the years that all of SFA5 has been surveyed, trends in indices and biological characteristics for the entire area and the Cartwright Channel portion were broadly consistent.

The SFA 5 survey fishable biomass index declined by 16% from 2006 to 2008. Fishable biomass in Cartwright Channel decreased by 40% in 2009; however, broad confidence intervals in 2009 indicate uncertainty (Fig. 13).

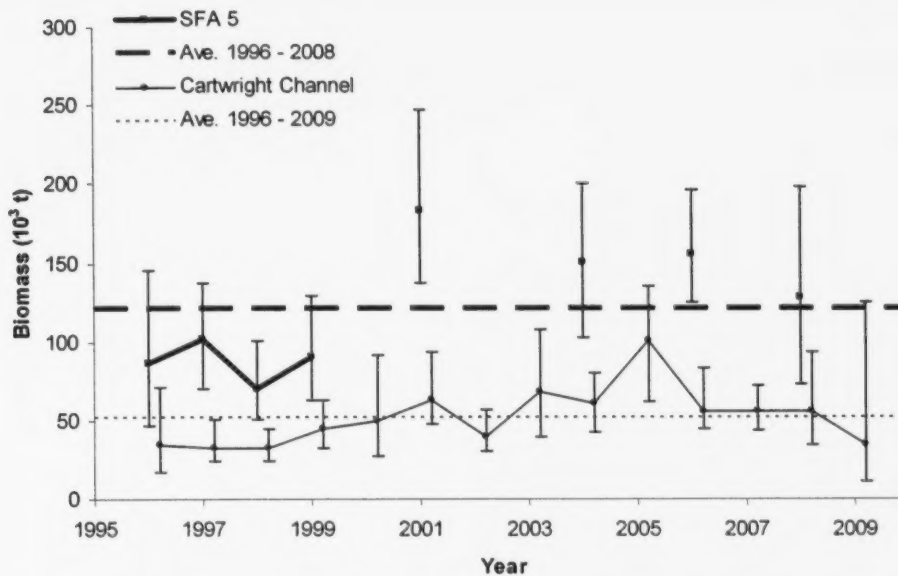


Figure 13. Fishable biomass index within the entire of SFA 5 and Cartwright Channel (error bars indicate 95% confidence intervals).

The SFA 5 SSB index after 2000 has been somewhat higher than before 2000; however, broad confidence intervals in 2008 indicate uncertainty (Fig 14).

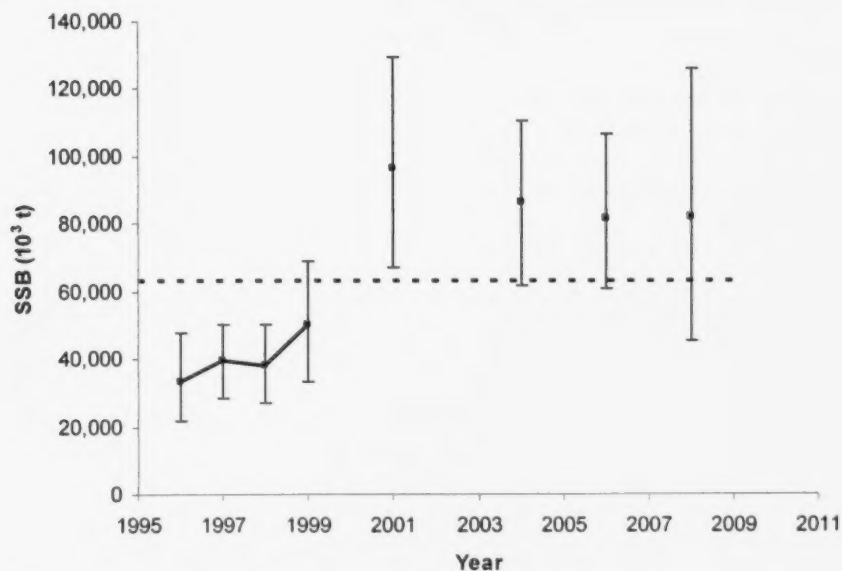


Figure 14. SSB index within SFA 5 (error bars indicate 95% confidence intervals).

Recruitment

The recruitment index in the short-term, while uncertain, appears average (Fig 15)

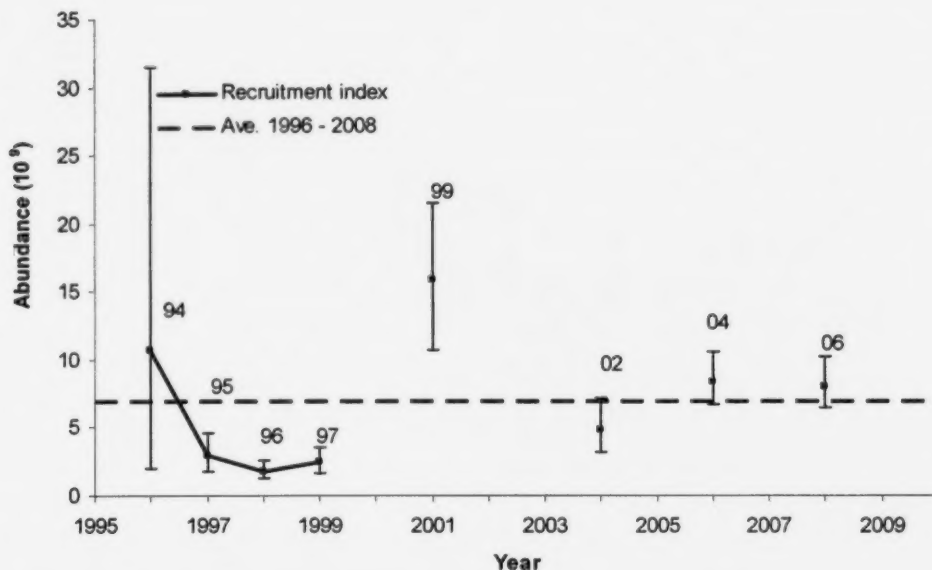


Figure 15. SFA 5 recruitment index (error bars indicate 95% confidence intervals; numbers denote year classes).

Mortality

Instantaneous mortality (Z) for females was estimated to be approximately 1, which equates to an annual mortality rate (A) of 63% per year.

Assuming that the 2009/10 TAC will be taken, the exploitation rate index will be 20%, slightly above the long term mean (Fig 16).

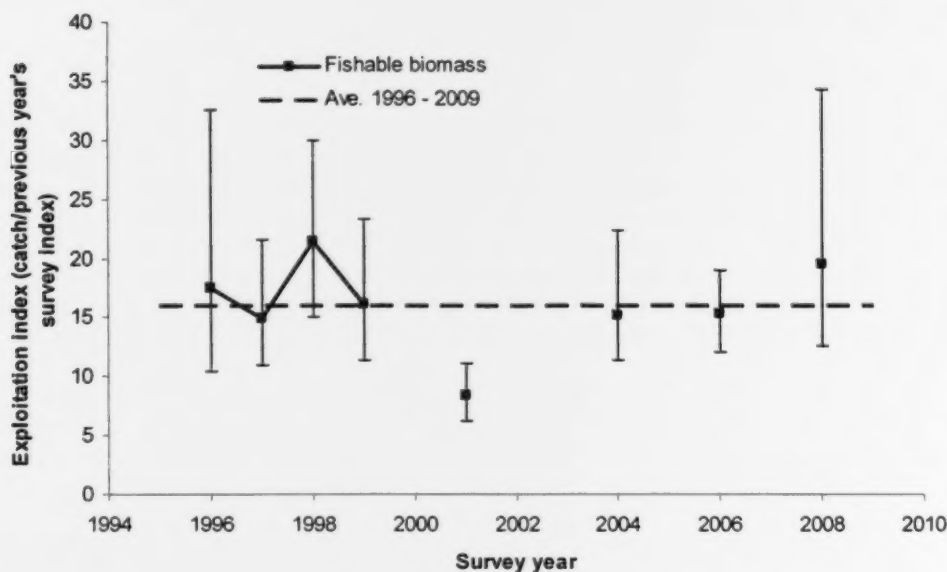


Figure 16. SFA 5 exploitation rate index over the period 1996 – 2009 (total catch/ fishable biomass index from the previous year; error bars indicate 95% confidence intervals).

In terms of the precautionary approach framework, SSB in SFA 5 was in the healthy zone in 2008, well above the provisional USR (Fig 17).

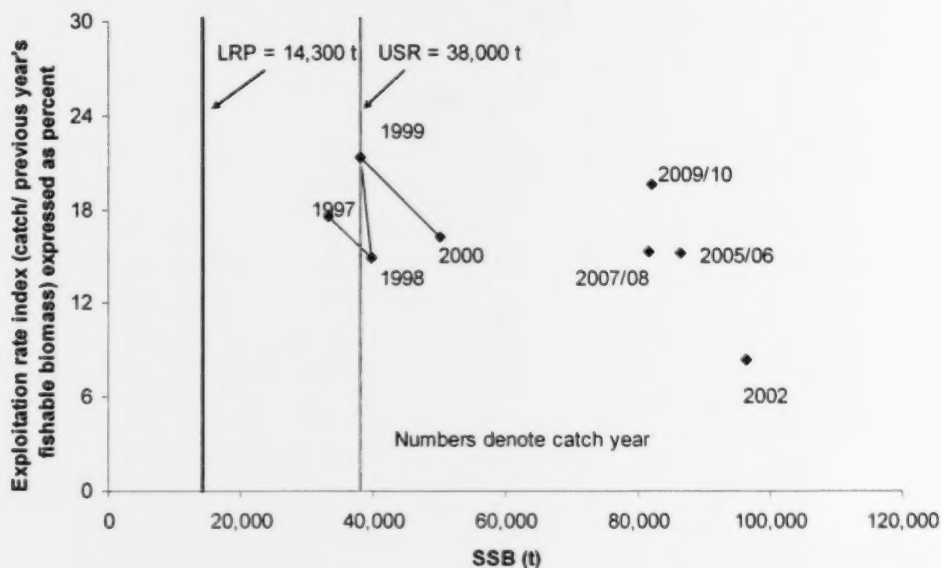


Figure 17. SFA 5 provisional precautionary approach framework with trajectory of exploitation rate index vs SSB.

SFA 4 (NAFO Division 2G)Commercial Fishery

The TAC increased from 2580 t in 1989 to 5200 t in 1995 and 8320 t in 1998 (Fig. 18). The 1998 TAC allocated 2184 t to the area south of 60°N to promote spatial expansion of the fishery. The 2003 TAC was increased to 10,320 t. In 2003 the management year changed to April 1 – March 31, and an additional interim quota of 2802 t was set for the period January 1 – March 31, 2004. Thus the 2003/04 management period was 15 months and had a 13,122 t TAC. The 10,320 t TAC was maintained through to 2007/08. The TAC was increased to 11,320 t in 2008/09 and maintained at that level in 2009/10. Approximately 10,000 t were taken during the 2009 calendar year and it is anticipated that the remainder of the TAC will be caught.

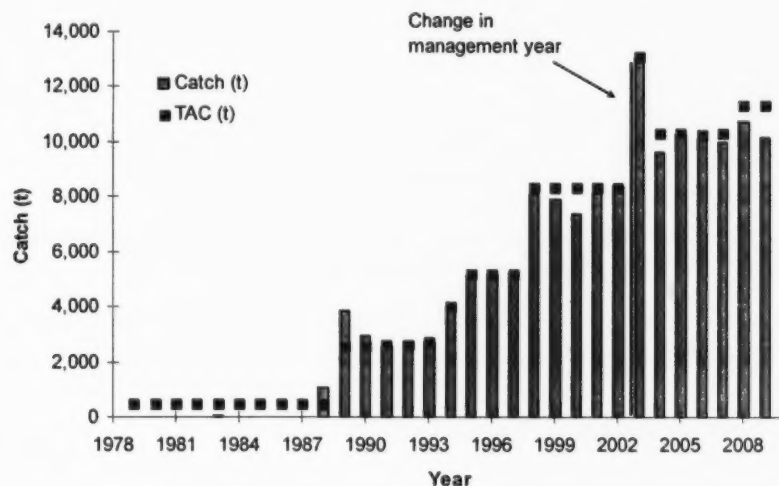


Figure 18. Historical northern shrimp catches (SFA 4) and the TAC for the period 1979-2010 (2009/10 catches are preliminary). In 2003, the management year changed to a fiscal year.

CPUE has increased since 2004/05 and is now well above the long term mean (Fig. 19).

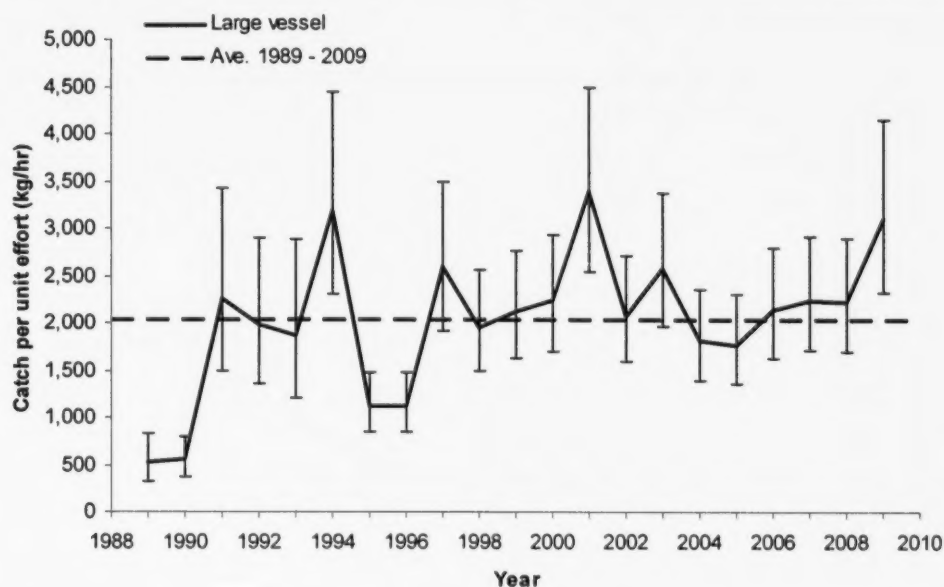


Figure 19. SFA 4 large vessel CPUE (error bars indicate 95% confidence intervals).

Percent total area fished within SFA 4 for the large (>500 t) vessel fleet to obtain 95% of their catch has changed little since 1998 (Fig. 20).

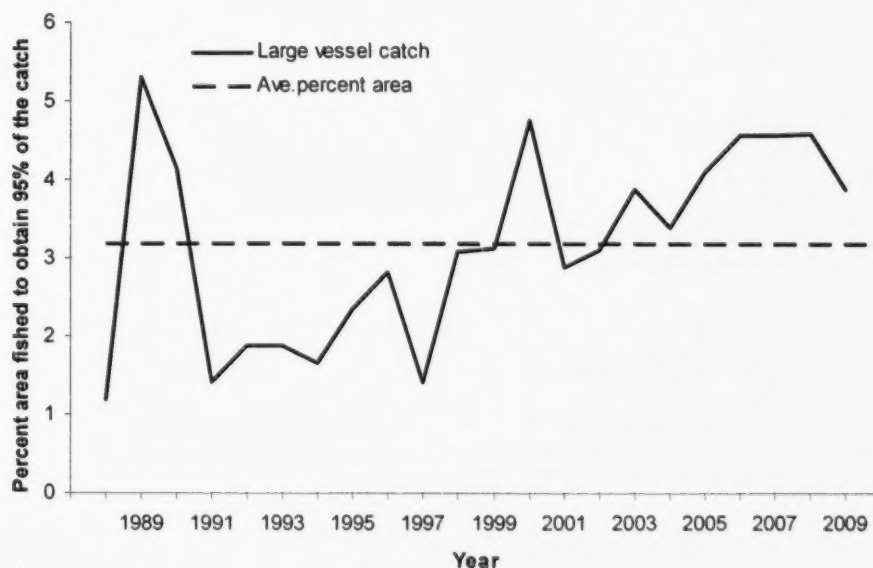


Figure 20. Percent of the total area available within SFA 4 necessary to account for 95% of large commercial catches over the period 1988 - 2009.

Biomass

The NSRF-DFO research survey biomass indices (SSB and fishable) have been increasing throughout the five-year time period (Fig 21).

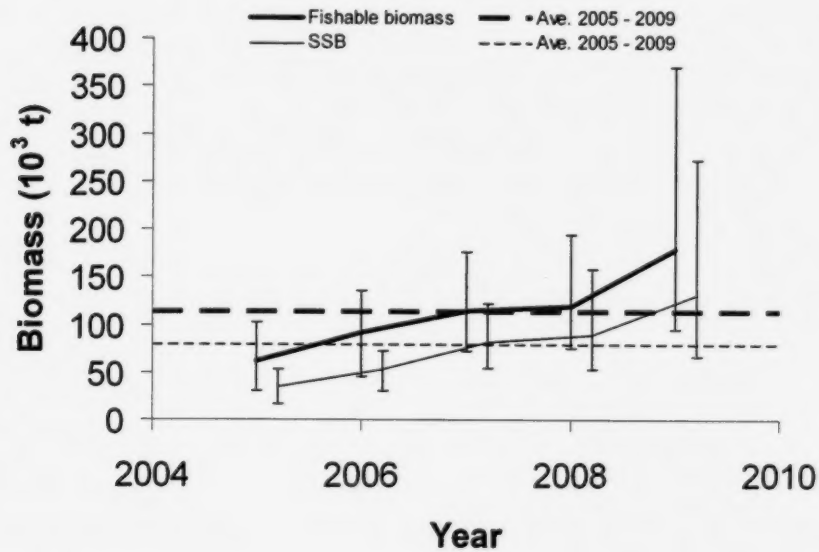


Figure 21. SFA 4 biomass index (error bars indicate 95% confidence intervals).

Recruitment

The recruitment index increased from 2005 to 2008 and has changed little in 2009 (Fig. 22).

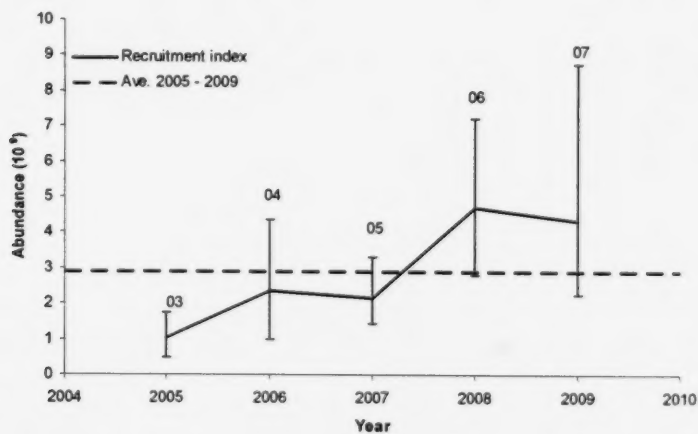


Figure 22. SFA 4 recruitment index (error bars indicate 95% confidence intervals; numbers denote year classes).

Mortality

Instantaneous mortality (Z) for females was estimated to be approximately .45, which equates to an annual mortality rate (A) of 37% per year.

Exploitation rate index has decreased from 16% in 2005 to 6% in 2009 (Fig. 23).

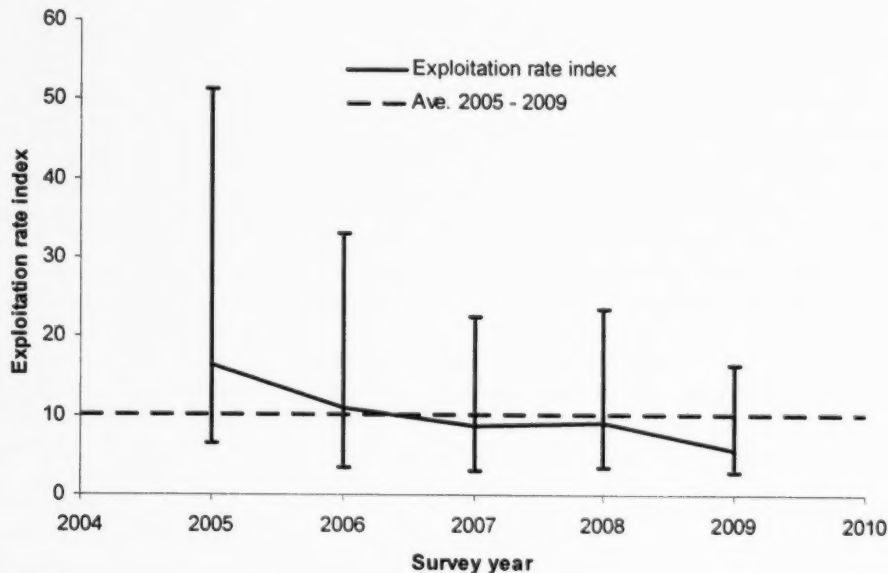


Figure 23. SFA 4 exploitation rate index. (total catch/ fishable biomass index from the same year; error bars indicate 95% confidence intervals).

In terms of the precautionary approach framework, SSB in SFA 4 was in the healthy zone in 2009, well above the provisional USR (Fig 24).

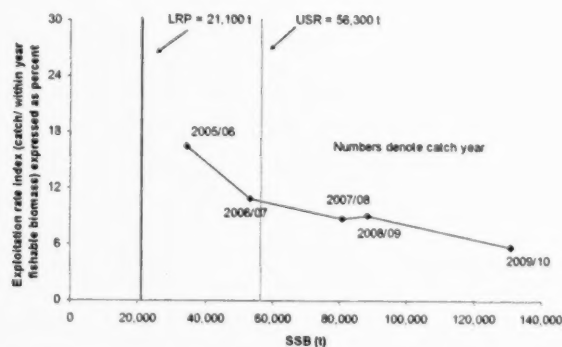


Figure 24. SFA 4 precautionary approach framework with trajectory of exploitation rate index vs SSB.

Current status appears positive from fishery and survey indices. Recent catch rates have been increasing and are above the long term mean (Fig. 20). It is anticipated that the TAC will be

taken. All of the survey indices are trending upward; however, confidence intervals around the 2009 survey indices are broad indicating uncertainty (Figs 21 and 22).

In terms of the provisional precautionary approach framework, SSB in SFA 4 was in the healthy zone in 2009, well above the provisional USR (Fig 23).

Industry Perspectives:

Small vessel shrimp fleet perspective

Inshore small vessel shrimp fleets target mainly SFA 6. Fishing activity by the inshore fleet is largely impacted by restrictions in fishing time, weather, ice conditions, vessel scheduling, enterprise expenses (i.e. fuel) and the price paid for shrimp. These factors also determine fishing locations and the segment of the shrimp population targeted (ie. economics may influence harvesters to target different size of shrimp depending on proximity to port or fishing area boundaries). Low landings in 2009 were not due to resource issues. The soaring expenses to operate an enterprise and more particularly, unfeasible shrimp prices paid to harvesters were the primary reasons for lack of effort and landings.

In recent years, harvesters have observed changes in shrimp behavior due to increased interactions with predators such as cod and turbot. As cod and turbot populations increase they are thought to be frequently displacing shrimp from the bottom at certain times, thus making them inaccessible to fishing gear.

Large vessel shrimp fleet perspective:

The offshore shrimp sector generally concurs with observations arising from the RV survey information. Good concentrations of fishable biomass seen in SFA6 virtually throughout the year over the past decade have been more variable in the past two seasons.

Resource conditions observed in SFAs 4 and 5 continue to be positive.

Sources of Uncertainty

The implications of finishing some autumn multi-species surveys later than usual are unknown.

The relationship between recruitment index and fishable biomass is uncertain.

Various methods were explored to determine shrimp mortality rates; mortality rates for females are uncertain and there are no mortality rates for males. Further work must be conducted on mortality rate estimation.

SFA 5 is surveyed in its entirety only biennially (NAFO Div. 2J annually, 2H biennially).

The shortness of the survey time series, lack of dynamic range and stock-recruit relationships limits modeling stock dynamics. There is no risk analysis for this resource and work to date on reference points has been preliminary. There is uncertainty in the utility of the provisional reference points.

Area closures may bias catch rate models as indicators of resource status.

Changes in the ecosystem (e.g., predator abundance) may affect the availability of shrimp to the trawl.

CONCLUSIONS AND ADVICE

The resource has been decreasing in the south but increasing in the north.

SFA 6

There is concern for the current status. The resource continues to be distributed over a broad area as inferred from the spatial distribution of commercial effort and survey catches. However, over the past 3 or 4 years, both the large and small vessel catch rates have been decreasing and are presently near their respective long term means. Biomass indices from fall multi-species surveys generally increased from 1997 to peak levels in 2006 but have since decreased by 50%. The present catch levels may not be sustainable given the declining biomass. If the current TAC is taken in 2010/11, the exploitation rate index would increase to between 20 and 37% (based on an 85,725 t TAC and 2009/10 fishable biomass 95% confidence intervals). SSB is presently within the cautious zone at 97% of the provisional USR.

SFA 5

Current status is uncertain. The distribution of the fishery has decreased over the last two years while the large vessel CPUE continues to fluctuate above the long term mean. There is concern that the SFA 5 survey fishable biomass index declined by 16% from 2006 to 2008 and decreased by 40% in 2009 in Cartwright Channel. The SFA 5 SSB index after 2000 was somewhat higher than before 2000; however, broad confidence intervals indicate uncertainty. Recruitment in the short-term, while uncertain, appears average. Exploitation rate index was 20% in 2008, slightly above the long term mean.

In terms of the precautionary approach framework, SSB in SFA 5 was in the healthy zone in 2008, well above the provisional USR.

SFA 4

Current status appears positive from fishery and survey indices. Recent catch rates have been increasing and are above the long term mean. It is anticipated that the TAC will be taken. All of the survey indices are trending upward; however, confidence intervals around the 2009 survey indices are broad indicating uncertainty.

In terms of the precautionary approach framework, SSB in SFA 4 was in the healthy zone in 2009, well above the provisional USR.

MANAGEMENT CONSIDERATIONS

Exploitation strategies for this resource should take into consideration the importance of shrimp as a forage species. As the resource declines, the proportion available for the fishery will decline.

SOURCES OF INFORMATION

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